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The Influence of Problem-Based Learning Approach on Students' Perceptions and Attitudes toward the Mole Concept in Tamale College of Education

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Abstract

The purpose of the study was to investigate the influence of problem-based learning (PBL) approach on students' perceptions and attitudes toward the mole concept in Tamale College of Education. The study was quasi-experimental research which employed a non-randomised selection of the research participants who were already organized into intact or pre-existing classes at the time of the study. Out of a total population of 543 first year teacher trainees of the college, 88 were purposively selected for the study. Fourty-four of the trainees were in "A" class and constituted the control group where Traditional Lecture-Based (TLB) approach was applied. The remaining 44 trainees were in the "K" class (experimental group) where the Problem-Based Learning approach was used. The instrument used for the study was the Mole Concept Perception and Attitude Scale (MCPAS) with a reliability coefficient of 0.851. The data were analysed using percentage scores and t-test and presented using tables. The results of the study revealed that students' perceptions and attitudes were positive toward the mole concept when the PBL approach was used in lesson delivery unlike the conventional TLB approach. The mean score of the experimental group using the PBL approach was significantly higher (69.4) than the mean score of the control group (54.7) using the TLB approach.

Keywords: experimental group, control group, general programme, perception

INTRODUCTION

Countless approaches and methodologies to teaching and learning have been developed and are being developed for use in educational practice. This is so because of the sophistication, dynamism and the socio-cultural environments of the players in the educational sector. Whilst it is true that no single approach to teaching and learning can claim to be perfect, it is not out of place to find some of the approaches best suit certain disciplines and concepts than others. One of such teaching and learning paradigms is the Problem-Based Learning. This paper examines the influence of the Problem-Based Learning (PBL) approach on students' perceptions and attitudes toward the mole concept.

Problem-based learning (PBL) model was developed at McMaster University in Canada in the late 1960s, consequently, many different varieties have emerged (De Graaff & Kolmos, 2003). PBL is an educational approach whereby the problem is the starting point of the learning process. Students are usually faced with problems that put them into thinking and planning as to how to devise strategies to solve such problems. PBL process paves way for students to build on their previous knowledge by creating new ideas that aid them proffer solutions to given problems. As explained in Hmelo-Silver and Barrows (2006), in the context of PBL, students have the opportunity to develop skills in reasoning and self-directed learning. In the context of the PBL approach, the teacher does not have the opportunity to dominate in the learning process. His or her role is minimal thus offering students the opportunity to direct their own learning. PBL sees a shift in educational focus from a teacher-centred approach to teaching and learning to a student-centred one, whereby students construct meaning for themselves by relating new concepts and ideas to previous knowledge (Finlayson & Kelly, 2007). The approach of the PBL is an organized one with its unique characteristics that does

not create room for learning to be carried out in a haphazard manner. Newman (2005) outlined the key features of problem-based learning to include learning in small groups, teacher as facilitator, appropriate assessment, and tutorial process to stimulate reflection, active participation and application as well as use of problems to stimulate or motivate, contextualize and integrate learning.

Problem-based learning as one of the instructional strategies is fast gaining ground as it has proven to be an effective teaching method that improves learners' performance. Problem-solving is the highest form of learning (Babatunde, 2008). Raimi and Adeoye (2004) contend that the superiority of problem based learning strategy over the conventional method also known as the traditional lecture-based (TBL) could be attributed to the logical and sequential manner with which instructions are presented in problem based technique and practical skills teaching. There are many concepts and topics in science disciplines, especially, chemistry which educationist regard as "difficult". The branding of these so called difficult topics is based on the fact that students do not perform well in them or teachers find it difficult teaching these topics. A typical example of such difficult concepts in chemistry is the 'mole concept'.

Furio, Azcona, Guisasola and Ratcliffe (2000) indicated that the mole concept was introduced by Ostwald at the beginning of the 20th century, with a meaning of weight (mass), in a context of skepticism towards Dalton's atomic hypothesis. Historically, the mole concept was introduced before the quantity 'amount of substance' for which it is the unit. The mole in recent times is expressed as a unit measuring the quantity 'amount of substance', at the same time; it is expressed as a number. For instance, one mole of a substance is expressed as the Avogadro's number or constant which is 6.02×10^{23}. This expression of the mole concept creates confusion and difficulty for students when studying it. According to Case and Fraser (1999), students have acute difficulties in

dealing with the abstract concepts required of them to perform stoichiometric calculations using the mole concept. A study by Staver and Lumpe (1995) reveal that some students identify the mole with number of particles, while others identify it with mass in grams, even though the mole concept has been defined according to the International System. The operative definitions of the mole as a concept are expressed through the relations to mass, to volume or to the number of elementary entities: $n = m/M$; $n = V/V_m$; $n = N/N_A$ where the connections of 'n' with 'm', 'V' or 'N_A' are established (where M is the molar mass, Vm the molar volume, N_A the Avogadro constant, *'n'* is the amount of substance, *'m'* is the mass, *'V'* is the volume and *'N'* is the elementary entities).

The abstract nature of the mole concept has further become problematic by the kind of perceptions and attitudes that students hold toward it. Attitude comprises three elements such as feeling, belief, and action. Perception on the other hand includes selection, organization, and interpretation (Pickens, 2011 cited in Özbaşa, 2016). Perception is closely related with attitude and during perception; awareness and acceptance towards stimuli play an important role. The role of perception and attitude that students bring to bear on concepts they learn cannot be over-emphasised. In fact, Kubiattco et.al (2012) has established that there is a strong positive correlation between learner's perceptions and their academic achievement. Therefore, any teaching method that can positively influence students' perceptions and attitudes toward difficult concepts like the mole concept is worth exploring.

Chepkorir (2013) asserts that students themselves contribute to their own failure in chemistry. Negative attitudes, lack of interest and lack of confidence are all contributing factors. The study argues that some of the causes of students' negative attitudes towards learning chemistry include wide coverage of syllabus, low awareness of career

opportunities in the subject, lack of exposure to well-equipped laboratory as well as poor teaching methods. According to Chambers (2004), the norms and values of a particular peer group make a difference to the school attainment and involvement of students. This implies a student whose friends work hard is likely to work hard as well. Factors contributing to students' persistent poor performance or under achievement in chemistry include gender stereotyping, poor attitudes towards the subject and low numerical ability (Ubom, 2003). According to Mulford and Robinson (2002), the students' self-developed concepts do not match up with the scientific theories. Students have their own misconceptions about certain concepts in science that do not reflect the real scientific theories about those concepts, thus influencing their perceptions and attitudes toward those concepts.

This study is situated within the constructivist theory. The origins of constructivism are believed to date back to the time of Socrates, who maintained that teachers and learners should talk with one another, interpret and construct the hidden knowledge by asking questions (Hilav, cited in Erdem, 2001). Lutz and Huitt (2004) believe that, the developmental theories of Dewey, Piaget, Vygotsky, and Bruner provide the basis for the educational application of constructivism. According to Kibos, Wachanga and Changeiywo (2015), in the constructivist classroom, the teachers' role is to organize situations which will allow the learners to hypothesize, predict, manipulate objects, pose questions, research, investigate and invent meanings. A constructivist classroom is student centered placing more value on student learning rather than the teacher teaching. As a learner-centred method that challenges the learner to take a progressively increasing responsibility for his or her own learning, PBL is therefore consistent with the constructivist theory (Coombs & Elden, 2004).

The problem addressed by this study is the poor attitudes and the negative perceptions that teacher trainees of Tamale College of Education have toward the mole concept. The researchers are chemistry tutors in the College and are familiar with the challenges trainees of the college face in chemistry. The mole concept is among the few concepts that the general (non-elective science students) dread so much. Just the mention of the name of the concept 'mole' receives spontaneous screams, puffs and confused facial expressions. This poor attitudes and negative perceptions reflect in their internal and external examinations.

The purpose of the study therefore, was to investigate the influence of problem-based learning approach on students' perceptions and attitudes toward the mole concept in Tamale College of Education. The research question that the study sought to answer was; what are the students' perceptions and attitudes toward the mole concept using the PBL and the TLB approaches?

The outcome of this study which this paper seeks to bring to the fore, will guide science tutors to use such innovative teaching approach to teach difficult topics that many times cause students to panic and exhibit unnecessary anxiety in the process of learning. It will also be a guide to the students themselves to adopt the PBL approach to minimize or eradicate the fears they exhibit when faced with difficult concepts or topics in their learning process.

METHODOLOGY

The study was hinged on the constructivist methodologies where learners construct knowledge for themselves. Problem-based learning (PBL) model (which is directly linked to the constructivist model of learning) was developed at McMaster University in Canada in the late 1960s, (De Graaff & Kolmos, 2003) and in this model; students are

usually faced with problems that put them into thinking and planning as to how to devise strategies to solve such problems.

The research design was quasi-experimental thus research participants were not randomly assigned. This design was used because two groups were compared where the experimental group and control group participants were in already existing or intact classrooms at the time of the research that needed not to be disrupted for the purpose of the research. Ary, Jacobs and Razavieh (2002) noted that "in a typical school situation, schedules cannot be disrupted nor classes reorganized to accommodate a research study, in such a case it is necessary to use groups as they are already organized into classes or other preexisting intact groups" (p. 316). The experimental group was the intact class where the mole concept was taught using the PBL approach. The control group was the other already existing class where the mole concept was taught using the TLB approach. Out of 543 first year students of Tamale College of Education 88 General Programme students were selected for the study. Each intact class was made up of 44 students. The selection process was non-randomised.

The instrument used to collect the data was the Mole Concept Perception and Attitude Scale (MCPAS). The MCPAS took the form of the Likert Scale type questionnaire and was used to collect data on the students' perceptions and attitudes toward the mole concept. The MCPAS questionnaire was administered to both the experimental and control groups after the mole concept was taught using the PBL and TLB approaches respectively. They were ten items on the scale comprising both positive and negative statements and a 5-point Likert scale was used. For example, some of the items were stated as "the mole concept is easy; SA = 5, A = 4, U = 3, D = 2, SD = 1" as a positive statement and "the terms used in the mole concept are scaring; SA = 1, A = 2, U = 3, D = 4 and SD = 5" as a negative statement. The participants were asked to respond to a

series of the statements by indicating Strongly Agrees (SA), Agrees (A), Undecided (U), Disagrees (D), or Strongly Disagrees (SD) to each statement.

Per the students' rating of their perceptions and attitudes toward the mole concept, the 5-point Likert scale was re-organised to 3-point Likert scale during the analysis of the data using percentages. Thus strongly agree (SA) and agree (A) responses were combined as one to indicate agree and the strongly disagree (SD) and disagree were also combined as one to indicate disagree. However, the responses for undecided still remained as they were. The data were analysed using frequency distribution statistics where the percentages for agree, undecided and disagree were presented using tables. The students' perceptions and attitudes toward the mole concept were determined based on the percentage scores.

The reliability coefficient of the MCPAS instrument was 0.851 and its validity was ascertained as the instrument was reviewed by experts from the University of Education, Winneba and Tamale College of education to ensure that the items were valid before administering them on the research participants.

RESULTS

Research question: what are the students' perceptions and attitude towards the mole concept using the PBL and the TLB approaches?

The students' perceptions and attitudes toward the mole concept using PBL and TLB approaches were determined based on percentage scores. The students' perceptions and attitudes rating of the mole concept in the experimental group using the PBL approach was examined (Table 1). The rating was carried out after the students were taught the mole concept in the PBL environment.

The results reveal that 88.7 % of the students agreed that the mole concept is easy, 6.8 % disagreed whilst 4.5 % of them were undecided. 95.4 % of the students indicated that

they are comfortable when learning the mole concept while 2.3 % of them disagreed and 2.3 % were undecided. 27.3 % of the students did indicate that they wish they do not have to take a course in chemistry, 54.5 % disagreed and 18.2 % were undecided. A good percentage of the students did not support the view that the terms used in the mole concept are scaring, 90.9 % of the students disagreed, 6.8 % agreed whilst 2.3 % were undecided. 95.5 % of the students also agreed that they can do well in mole concept exams, 2.3 % of them were undecided while 2.3 % disagreed. 88.6 % of the students agreed that they enjoy solving problems relating to the mole concept, 6.8 % were undecided, but 4.5 % disagreed. The statement that mole concept lessons are boring; 95.5 % of the students disagreed with it, 4.5 % agreed and none was undecided about it. 84.1 % of the students agreed that they easily understand the symbols and units used in the mole concept, 6.8 % were undecided and 9.1 % disagreed. The perception that the mole concept is confusing; 68.2 % of the students disagreed, 27.3 % agreed and 4.5 % were undecided. Finally, on the item that the mole concept is for pure science students, 84.1 % disagreed, but 11.4 % agreed whilst 4.5 % were undecided.

Table 1: Students' Perceptions and Attitudes Rating of the Mole Concept in the Experimental Group using PBL Approach

No.	Perception and Attitude Items	Agree (%)	Undecided (%)	Disagree (%)	Total (%)
1.	The mole concept is easy	88.7	4.5	6.8	100
2.	I am comfortable learning the mole concept	95.4	2.3	2.3	100
3.	I wish I do not have to take a course in chemistry	27.3	18.2	54.5	100
4.	The terms used in the mole	6.8	2.3	90.9	100

	concept are scaring				
5.	I can do well in mole concept examination	95.4	2.3	2.3	100
6.	I enjoy solving problems relating to the mole concept	88.6	6.8	4.5	100
7.	Mole concept lessons are boring	0.0	4.5	95.5	100
8.	I easily understand the symbols and units used in the mole concept	84.1	6.8	9.1	100
9.	The mole concept is confusing	27.3	4.5	68.2	100
10.	The mole concept is for pure science students	11.4	4.5	84.1	100

Sample size (N) = 44.

In the control group where the TLB approach was the intervention, the students' perceptions and attitudes toward the mole concept were rated in terms of percentage scores (Table 2). The statement that the mole concept is easy, 47.7 % of the students disagreed, 40.9 % agreed while 11.4 % were undecided. Regarding the attitude that I am comfortable learning the mole concept, 52.3 % of the students agreed to it, while 13.6 % were undecided, and 34.1 % disagreed. I wish I do not have to take a course in chemistry; 50.0 % of the students agreed to this statement, 11.4 % were undecided whilst 38.6 % disagreed. 52.3 % of the students agreed to the view that the terms used in the mole concept are scaring, 43.2 % disagreed and 4.5 % were undecided. 59.1 % of the students also agreed that they can do well in mole concept examinations, 11.4 % were undecided and 29.5 % disagreed. Again, 52.3 % of the students disagreed that they

enjoy solving problems relating to the mole concept, 29.5 % agreed whereas 18.2 % were undecided. The statement that mole concept lessons are boring, 36.4 % agreed to it, 11.4 % were undecided whereas 52.2 % disagreed. I easily understand the symbols and units used in the mole concept; 59.1 % agreed to this statement, 6.8 % were undecided and 34.1 % disagreed. Last, but not least, 68.2 % of the students agreed that the mole concept is confusing, 11.4 % were undecided and 20.4 % disagreed. Finally, the item that the mole concept is for pure science students; 63.6 % of the students agreed to it, 4.5 % were undecided and 31.9 % disagreed.

Table 2: Students' Perceptions and Attitudes Rating of the Mole Concept in the Control Group using TLB Approach

No.	Perception and Attitude Items	Agree (%)	Undecided (%)	Disagree (%)	Total (%)
1.	The mole concept is easy	40.9	11.4	47.7	100
2.	I am comfortable learning the mole concept	52.3	13.6	34.1	100
3.	I wish I did not have to take a course containing chemistry	50.0	11.4	38.6	100
4.	The terms used in the mole concept are scaring	52.3	4.5	43.2	100
5.	I can do well in mole concept exams	59.1	11.4	29.5	100
6.	I enjoy solving problems relating to the mole concept	29.5	18.2	52.3	100
7.	Mole concept lessons are boring	36.4	11.4	52.2	100
8.	I easily understand the symbols	59.1	6.8	34.1	100

	and units used in the mole concept				
9.	The mole concept is confusing	68.2	11.4	20.4	100
10.	The mole concept is for pure science students	63.6	4.5	31.9	100

Sample size (N) = 44.

In finding out the difference between the students' perceptions and attitudes toward the mole concept using the PBL and the TLB methods, the unpaired samples t-test was used to determine which treatment method yielded positive perception and attitude generally. The responses from the Likert scale-based questionnaires by the students in the experimental and control groups were quantified as scores for the t-test analysis between the two groups. The results (Table 3) reveal that there was a significant difference between the students' perceptions and attitudes toward the mole concept using the PBL in the experimental group and the TLB in the control group. The mean score of the experimental group was significantly higher than the mean score of the control group (p = 0.000). The gain in the mean score of the experimental group over the control group reveals that the students showed positive perception and attitude toward the mole concept when the PBL intervention was used than those in the control group where the method was the TLB.

Table 3: Unpaired Samples t-test of the Students' Perceptions and Attitudes toward the Mole Concept

Group	N	M	SD	df	*t-value*	*p-value*
Experimental	44	69.4	9.16	86	6.921	0.000
Control	44	54.7	10.74			

DISCUSSIONS

The mole concept is considered difficult for students studying it as revealed by researchers. The difficulty level of a concept by students is dependent on several factors. The teaching method can create unnecessary anxiety in students that can leave them with negative attitudes toward whatever they are learning and the consequential effect will be under achievement. According to Njoku (2004), prominent among the contributing factors to students' persistent poor performance or under achievement in Chemistry include ineffective teaching methods or approaches used by science teachers to teach the subject.

The PBL approach adopted in this study resulted in positive perceptions and attitudes of the students toward the mole concept. 88.7 % of the students rated the mole concept to be easy and 99.5 % realized that they are comfortable learning it. However, among the group of students who were taught the mole concept using the TLB approach, 40.9 % agreed that the mole concept is easy with 52.3 % agreeing that they are comfortable learning it. Reference to the percentage differences, the students' perceptions and attitudes toward the mole concept is positive and better with the PBL approach than the TLB approach. This study outcome is in line with a study by Uzuntiryaki and Geban (2004) which indicate that students instructed by the constructivist approach had more positive attitudes toward chemistry as a school subject than students taught by the traditionally designed chemistry instruction. PBL is a teaching approach that is consistent with the constructivist approach. It gives students the opportunity to learn in small groups whilst the teacher serves as facilitator. It is also an approach where there is peer tutorial process to stimulate reflection and active participation among students that result in higher academic achievement. PBL approach therefore has the power to

positively influence the perceptions and attitudes of Tamale College of Education students toward the mole concept.

In the control group where TLB approach was used, there was no much change in the perceptions and attitudes of the students toward the mole concept. 52.3 % of the students still maintained their view that the terms used in the mole concept are scaring and 68.2 % of them held the view that the mole concept is confusing. In addition, 63.6 % of the students are of the opinion that the mole concept is for pure science students whilst 52.3 % disagreed that they enjoy solving problems relating to the mole concept. This implies the TLB approach could not positively influence the perceptions and the attitudes of the students toward the mole concept to a large extent. This study outcome is supported by Chepkorir (2013), which asserts that students themselves contribute to their own failure in Chemistry. Their negative attitudes, lack of interest and lack of confidence are all contributing factors. To change this attitude, there is the need for a teaching approach that is student-centred and that ensures self-directed learning as well as meaningful construction of the learning material by the students themselves whereby the role of the teacher is just being a facilitator. PBL is better situated to change students' perception and attitude toward the mole concept as revealed by this study. Larson (1997) argues that students may fail to construct meaningful understandings of the mole concept for the following reasons: inconsistency between the instructional approaches of the textbook and teacher, confusing mole concept vocabulary, students' mathematical anxiety, learners' cognitive levels, and lack of practice in problem-solving. Still in line with the students' poor attitudes and negative perceptions toward the mole concept using the TLB approach, a study by Polancos (2009) contends that the mole concept is an area that very few students like and succeed at, and which most students hate and struggle with because of their dislike for mathematics.

Contrary to the perceptions and attitudes of the students toward the mole concept using the TLB approach, in the PBL class, 90.9 % of the students disagreed that the terms used in the mole concept are scaring and 84.1 % also disagreed that the mole concept is for pure science students, instead, 88.6 % of the students agreed that they enjoy solving problems relating to the mole concept. These percentages rating suffice the effectiveness of the PBL approach in influencing positively the students' perception and attitude toward the mole concept. The results of this study confirm an inquiry-based study which is synonymous with PBL by Pedretti (2010), a study on the effects of inquiry-based activities on attitudes and conceptual understanding of stoichiometric problem-solving in high school chemistry. The result reveals that the students' attitudes toward mole calculations improved after using an inquiry-based activity.

The unpaired samples t-test reveals that there was a significant difference between the students' perceptions and attitudes toward the mole concept using the PBL in the experimental group and the TLB in the control group. The mean score of the experimental group was significantly higher than the mean score of the control group. Therefore the PBL approach resulted in a positive attitudes and perceptions among students of Tamale College of Education toward the mole concept. The result of this study is backed by the study of Erifyli and Georgios (2000) which contend that the superiority of the constructivist method of teaching to the traditional method could be attributed to the active participation of students in all processes of learning. This develops a positive attitude of students towards chemistry, and consequently results in higher achievement. The study further point out that the passive role that the receptive, teacher-centred method also known as the TLB approach reserves for students leads to many of them experiencing boredom, decrease in interest and develop a negative attitude towards chemistry, thus resulting in lower achievement.

CONCLUSIONS

The adoption of the PBL approach in teaching First year students of Tamale College of Education resulted in development of positive attitudes and perceptions toward the mole concept. The long standing anxiety, lack of interest and dislike for the mole concept among the students which hitherto affected their achievement have positively been influenced by the PBL approach. The PBL approach with its unique characteristics of students' learning in small groups, teacher as facilitator, appropriate assessment, and tutorial process to stimulate reflection, active participation and application as well as use of problems to stimulate, contextualize and integrate learning has impacted good attitudes and positive perceptions of the students toward the mole concept.

The traditional lecture-based approach remains an ineffective method in influencing the attitudes and perceptions of the students toward the mole concept. Owing to its inherent characteristics of teacher-centredness and lack of co-operative learning among students, it leads to many of them experiencing boredom; decrease in interest and development of negative attitudes towards chemistry and for that matter the mole concept, thus resulting in lower achievement.

RECOMMENDATIONS

The researchers therefore recommend a longitudinal study into the use of the PBL approach in teaching concepts in chemistry deemed difficult. Science tutors and students alike in colleges of education are recommended to use the problem-based learning approach in teaching and learning of chemistry concepts. This will go a long way to impart positive attitudes and perceptions on students toward chemistry and science in general.

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REFERENCES

Ary, D., Jacobs, L. C., & Razavieh, A. (2002). *Introduction to Research in Education* (6th ed.). USA, Wadsworth.

Babatunde, A. A. (2008). Effects of cooperative learning and problem-solving strategies on junior secondary school student' achievement in social studies. *Electronic Journal of Research in Educational Psychology,* 6(3), 691-708.

Case, J. M., & Fraser, D. M. (1999). An investigation into chemical engineering students' understanding of the mole and the use of concrete activities to promote conceptual change. *International Journal of Science Education*, 21(12), 1237–1249.

Chambers, D. (2004). Peer regulation of teenage sexual identities. *Gender and Education,* 16(3): 397- 415.

Chepkorir, S. (2013). The impact of students' attitudes on the teaching and learning of chemistry in secondary schools in Bureti District, Kenya. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)* 4(4), 618-626.

Coombs G., & Elden M., (2004), Introduction to the special issue: Problem-Based Learning as social inquiry-PBL and management education, *Journal of Management Education*, 28, 523-535.

De Graaff, E., & Kolmos, A. (2003). Characteristics of problem-based learning. *Int. J. Engng Ed.* 19(5), 657-662.

Erdem, E. (2001). *Program gelistirmede yapilandirmacilik yaklasum*. Constructivist approach in curriculum development. Unpublished master thesis. Hacettepe Univerisity, Ankara.

Erifyli, Z., & Georgios, T. (2000). Teaching lower-secondary chemistry with a Piagetian constructivist and an Ausbelian meaningful-receptive method: a longitudinal comparison. *Chemistry Education: Research and Practice in Europe* 1(1), 37-50.

Finlayson, O. E., & Kelly, O. C. (2007). Providing solutions through problem-based learning for the undergraduate 1st year chemistry laboratory. *Chemistry Education Research and Practice*, 8 (3), 347-361.

Furio, C., Azcona, R., Guisasola, J., & Ratcliffe, M. (2000). Difficulties in teaching the concepts of 'amount of substance' and 'mole'. *International Journal of Science Education,* 22 (12), 1285- 1304.

Hmelo-Silver, E. C., & Barrows, S. H. (2006). Goals and strategies of a problem-based learning facilitator. *Interdisciplinary Journal of Problem-Based Learning* 1(1), 21-39.

Kibos, R. C., Wachanga, S. W., & Changeiywo, J. M. (2015). Effects of constructivist teaching approach on students' achievement in secondary school chemistry in Baringo North sub-county, Kenya. *International Journal of Advanced Research* 3 (7), 1037-1049.

Kubiatko M., Mrascova K. & Janko T. (2012). Gender and Grade level as factors influencing perceptions of geography. *Journal of review of International Geographical Education* 2 (3).

Larso, J. O. (1997, March). *Constructing Understandings of the Mole Concept: Interactions of Chemistry Text, Teacher and Learners*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Chicago, IL.

Lutz, S., & Huitt, W. (2004). Connecting cognitive development and constructivism: Implications from theory for instruction and assessment. *Constructivism in the Human Sciences,* 9(1), 67-90.

Mulford, D. R. & Robinson, W. R. (2002). An inventory for alternate conceptions among first-semester general chemistry students. *Journal of Chemical Education*, 79 (6), 739-744.

Newman, J. M. (2005). Problem based learning: an introduction and overview of the key features of the approach. *Journal of Veterinary Medicine* 32(1), 12-20.

Njoku, Z. C. (2004). Fostering the application of science educational research findings in Nigeria classrooms: strategies and needs for teachers' professional development. In *M.A.G Akale (Ed.). 45th Annual Conference Proceedings of Science Teachers' Association of Nigeria,* Ibadan: HEBN Publishers P/C.

Özbaşa, S. (2016). The high school students' perceptions and attitudes toward bioenergy. *International Journal of Environmental and Science Education,* 11 (10), 3201-3214

Pedretti, L. A. (2010). *The Effects of Inquiry-Based Activities on Attitudes and Conceptual Understanding of Stoichiometric Problem Solving in High School Chemistry.* A

Research Paper Submitted in Partial Fulfillment of the Requirements for the Master of Science Degree in Education.

Polancos, D. T. (2009). Effects of mathematics review on the learning of high school chemistry concept and on problem solving. *Liceo Journal of Higher Education Research*, 6 (1), 80- 99.

Raimi, S. M., & Adeoye, F. A. (2004). Problem based learning strategy and quantitative ability in college of education students' learning of integrated science. *Ilorin Journal of Education.*

Staver, J. R., & Lumpe, A. T. (1995). Two Investigations of students' understanding of the mole concept and its use in problem solving. *Journal of Research in Science Teaching*, *32*, 177-193.

Ubom, I. U. (2003). Attitudes of secondary school students in the learning of math and science. Implications for counseling interventions. Inc. Ekpo (Ed.). *Strategies for effective teaching and learning of STM education* (pp. 22-27). Uyo, Ivy Press Limited.

Uzuntiryaki, E., & Geban, O. (2004). Effectiveness of instruction based on constructivist approach on students' understanding of chemical bonding concepts. *Science Education International* 15 (3), 185-200